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INDICATION OF SPATIAL HETEROMORPHY AND COMMUNITY STRUCTURE OF *ACRIDOIDEA*-COMMUNITIES IN A SANDY GRASSLAND

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Abstract

The spatial heteromorphy indication of *Acridoidea*-communities was studied in 1983–84 on the basis of observations of dish-trap groups placed at 12 representative points of sandy grassland mosaic-complex.

The habitat points similar in their vegetational succession stage are also qualified as being of great similarity by the grashoppers. Grashopper communities plastically react to the changes in heteromorphy. The changes in their indication patterns is brought into connection with abiotic conditions as well as with the changes in individual number.

The diversity-studies refer to the patchily changing organization and the variable patterns of structures of communities.

The obtained results were compared with those of gained from previous Barber–trap method. These showed good correlation in general, despite the relative frequency is effected by the differences between the two methods.

Key words: Acridoidea, community structure, succession, indication of heterogeneity

Introduction

The grashoppers generally form significant herbivore guilds in the grass biocenoses (see ANDRZEJEWSKA and GYLLENBERG, 1980 as a review). Their significance is particularly great at the dry grasses of the Southern Great Hungarian Plain (GAUSZ, 1971–72), this gives reason for their detailed ecological processing at these habitats.

In this respect, it is found particularly important to study the effects of the changes — e.g. successional — taking place in the characteristics of the habitat exerted on its populations and communities. To decide the question it is evidently not enough to explore the *Acridoidea* populations and communities at synphenobiological level; it is also necessary to gain knowledge on the ecological background — first of all the vegetational characteristics (cp. CAPINERA and SECHRIST, 1982; EVANS et al. 1983; MONK, 1985, etc.).

The sandy plain belonging to the Kiskunság National Park — which is presently under complex ecological exploration (GALLÉ et al. 1985a, 1985b) — has favourable fundamentals for studies on the above-mentioned problem.

The principle question of our present paper is the examination of the similarities and dissimilarities between plant- and *Acridoidea*-communities in the community level reaction to spatial heteromorphy („heteromorphy-indication").

This was achieved in two ways. On the one hand, studies were performed on the „fine grained" and „coarse grained" behaviour of the two community types, on the basis of the similarity of the samples originating from the various patches. On the other hand, the diversity-relations of the communities living in the various patches of the habitat as well as the dependence of the *Acridoidea* diversities on the vegetational diversity were analysed.

The relationship between diversity and spatial heterogeneity has been pointed out by MURDOCH et al. (1972). SOUTHWOOD et al. (1979) have called attention to the connection of the diversity changes in the plant- and insect-communities, in the different stages of secondary succession. The diversity of specifically grashopper-communities has been studied by PFADT (1982, 1984).

Materials and methods

1. CHARACTERIZATION OF SAMPLING AREA

The area chosen for studies is a 2.4 ha of the Bugac sandy grassland belonging to the Kiskunság National Park, not being grazed since 1976. Its surface is heteromorph, containing 2–3 m high sand-hills and wind-furrows dissecting them. Beyond the surface heteromorphy, the heterogeneity of the vegetation is also due to a secondary successional process resulted by the cessation of grazing. The plant-association reflecting the effect of grazing, the *Potentillo-Festucetum pseudovinae*, is the starting-point of a succession having two trends dependent on height of the habitat part in question. On the sand-dunes representing the higher level it turns into natural, open sandy grassland, *Festucetum vaginatae danubiale*, while into the closed, higher grassed *Molinio–Salicetum* association in the lower, more humid wind-furrows.

The initial stages of artificially induced (watering, removal of upper soil layer) successional processes were also studied at plots established for the purpose of field experiments.

2. SAMPLING METHODS

Barber–traps and dish-traps were used for the continuous studying of the insect-communities of the sample area. The results of the studies performed with Barber–traps have been reported on elsewhere (GALLÉ et al. 1985a, 1985b), in the present paper they are used for comparison.

The dish-traps were plastic vessels of 15 cm diameter and 6 cm height. These were placed in groups of five at 12 points of the sample area, lowered 2 cm deep in the soil. Ethylene-glycol was applied as killing-agent and the collections were repeated in two weeks' intervals. The traps functioned from May till October in the years 1983–84. 6971 individuals were sampled in 1983, and 2521 in 1984.

In 1983, the composition and total coverage of the vegetation, as well as the relative frequency of the various species were determined in a 2 x 2 m district in the area of the traps.

3. PROCESSING METHODS

The similarity between the various sampling points was determined by cluster analysis on the basis of the Renkonen and Czekanowski indexes. The „coarse grained" and „fine grained" behaviour, resp., are characterized by the average of the similarity indexes ($\bar{C}$) and their coefficients of variation $S_C/\bar{C}$ (GALLÉ et al. 1985b).

The Shannon function was applied for measuring diversity, and the dominance-diversity curves based on the species-individual distribution were also applied for the further characterisation of the community-structure.

In every case the correlation studies were carried out on the basis of the linear (L), logarithmic (LOG), exponential (EXP) and power index (POW) functions.

Results and discussion

1. HABITATS

Vegetation types found at the sample are shown in Table 1. Signs in the Table: The relation signs refer to the dominant plant-communities at the places with mixed stand. The fine deviations in the different patches are demonstrated by the indication of the species participating to a considerable degree in the coverage (CY: *Cynodon dactylon*; ME: *Medicago minima*; CA: *Carex liparicarpos*; EU: *Euphorbia sequieriana*; SE: *Sedum acre*; GA: *Galium verum*). The point labelled FV/PFP/<SE represents a habitat of characteristic composition, where the *Sedum acre* appears with higher individual number than the *Festuca*. The dominating species at the 1. and 2. sampling site being close to primary successional stage is the *Euphorbia sequieriana* (EU) in one case, and the *Cynodon dactylon* (CY) in the other. According to the total coverage values the joint characteristic of the listed sites (with the exception of the two MSR variants) is the relatively low surfaced coverage, ranging between 0.3–0.6.

Table 1. Vegetational data of the sampling sites

Serial Number	Community type	Coverage	Space-level Difference	Experimental effects
1.	EU	0.15	+	removal of upper soil layer in 1981
2.	CY	0.30	+ +	
4.	PFP	0.30	+ +	
3.	PFP>FV	0.30	+ + +	
12.	PFP>FV(CY)	0.50	+ +	
11.	FV>PFP	0.35	+ +	watering isolated in 1984
10.	FV>PFP(CA)	0.45	+	
9.	FV>PFP(ME)	0.65	+	
5.	FV(PFP)<SE	0.50	+ + +	
7.	FV>PFP(CY)	0.60	+ +	
6.	FV⩾PFP	0.20	+ +	
8.	FV⩾EU	0.40	+	
13.	MSR(GA)	0.95	–	
14.	MSR(CY)	0.95	–	

The number of + signs increases with the raise of the space-level.

2. HABITAT-HETEROMORPHY INDICATION

Fig. 1. shows the dendrogram of the cluster analysis between the sites carried out on the basis of the percental coverage values of the plant species. It can be seen that the similarity levels of the dendogram link the habitats having *Festucetum vaginatae* (FV) dominance into groups similar in 72–86, and 73–76%, resp. The looser linkage of the FV/PFP/ < SE type habitat is due to its characteristic vegetation.

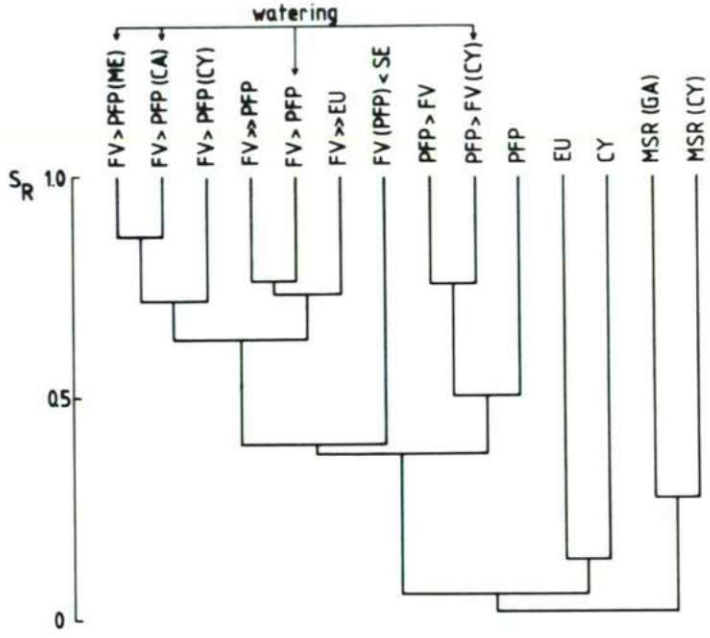

Fig. 1. Dendrogram of the vegatation according to Renkonen similarity analysis.

The segregation of the group of PFP and PFP>-like patches, and their lower (51–76%) similarity are well reflected. The characteristic vegetation of the nearby primary succession- (EU and CY) and *Molinio–Salicetum* (MSR)-type habitats is expressed in the low leveled similarity relationships (13.6 and 17.3%, resp.).

Therefore, the clusters of the dendrogram form groups according to the successional stages of the area. The majority of the sample sites of the present study represent a series of successional states being prior to the development of the sand-dunes, seminatural grassland of the *Festucetum vaginatae*, and the habitats of lower level included in the study in 1984 show patterns already segregated from the PFP- > MSR transition, which have reached a later successional stage.

The spatial heterogeneity qualification of the *Acridoidea*-communities in the above-mentioned habitat-combination was also studied by cluster analysis, both in 1983 and 1984 (Figs. 2 and 3). Distribution similar to that gained for the plants was

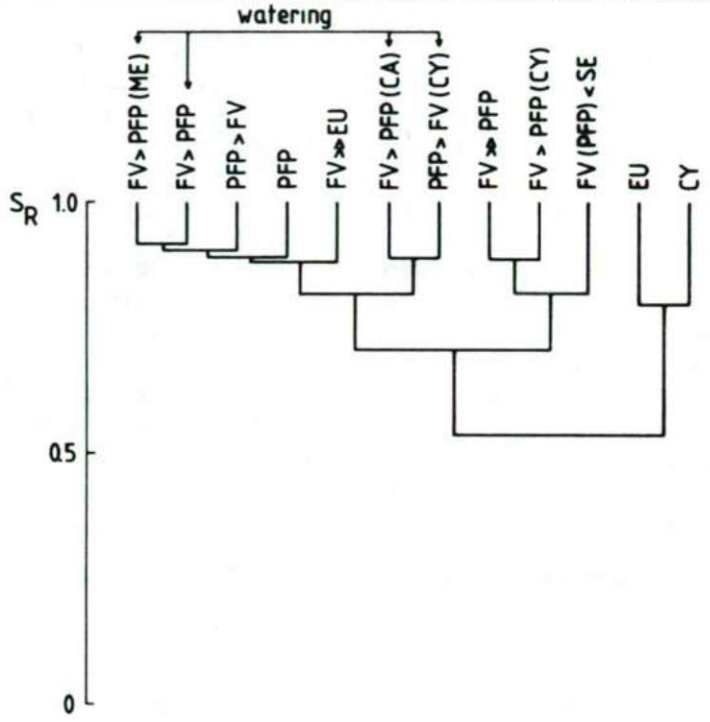

Fig. 2. Dendrogram of *Acridoidea*-communities according to Renkonen similarity analysis in 1983.

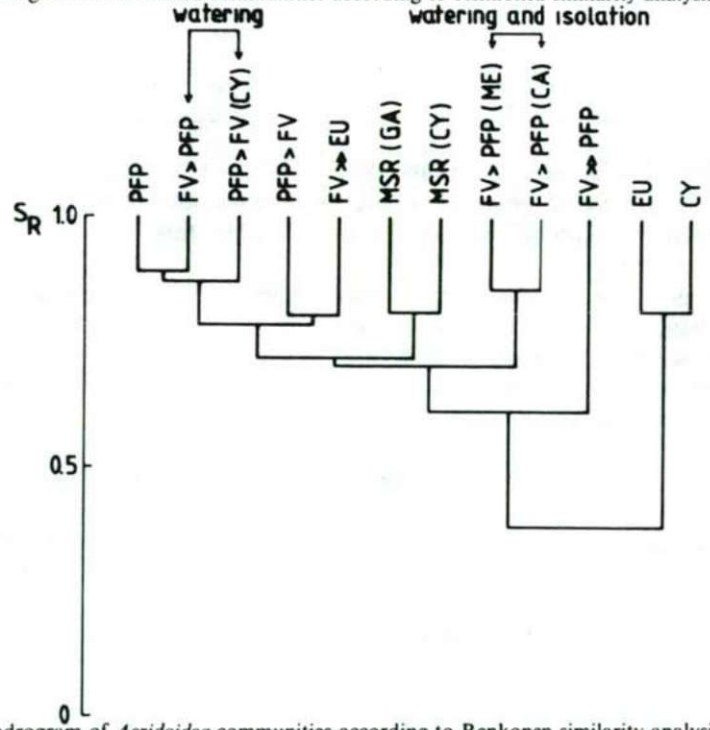

Fig. 3. Dendrogram of *Acridoidea*-communities according to Renkonen similarity analysis in 1984.

only partially observable between the habitats on the basis of grashoppers. Even the grashoppers make distinction at places where there are greater differences in vegetation or height — e.g. segregation of MSR and primary succession-close (EU and CY) habitats — but contrary to the plants, the similarity relations are of higher level here, too.

Accordingly, the similarity analyses refer to the fact that the grashoppers regard the habitat more homogeneous than the vegetation. This is well reflected by the elemental means of the similarity matrices ($\bar{C}$) as well as the variational coefficient values $S_C/\bar{C}$. Namely, it is evident that the finer indicational sensitivity, the realization of the „coarse grained response" is indicated by the lower similarity average and higher variational coefficient.

During the course of the similar evaluation pertaining to the Barber–trap recordings (GALLÉ et al. 1985b) it was manifested that the vegetation has better indicational ability compared to the animal communities, since the highest variational coefficient value was obtained for the vegetation($S_C/\bar{C} = 1$). This is confirmed by the present analysis (Table 2).

Table 2. Similarity averages and variational coefficients calculated from the Renkonen similarity matrix of the vegetation

		$\bar{C}$	$S_C/\bar{C}$
Dish–trap :	1983	35.77	0.74
	1984	24.31	1.15
Barber–trap :	1981	26.00	1.00

The deviation between the years 1983 and 1984 is caused by the fact that in 1984 two *Molinio–Salicetum*-covered patches were included in our studies, being of extreme character compared to the previous ones, and this is evidently apparent in the similarity means.

The grashopper communities and their seasonal changes were also studied by similar technique. Besides the data of the Renkonen similarity matrices, the $\bar{C}$ and $S_C/\bar{C}$ values were analysed according to the Czekanowski method as well. Since there is only slight deviation between the values obtained by the two methods, only the result of the Renkonen analysis is demonstrated (Fig. 4).

The deviations for 1983 and 1984 in the heteromorphic indication are similar to those of the vegetation here, too, and can with all probability be traced back to the previously mentioned causes.

According to Fig. 4. differences are demonstrable in the $\bar{C}$ and $S_C/\bar{C}$ values. As there are also differences in the individual numbers collected throughout the two years, this raises the possibility of the density-dependence of the heteromorphic indication. The data of the Barber–trap recordings are suitable for studying this

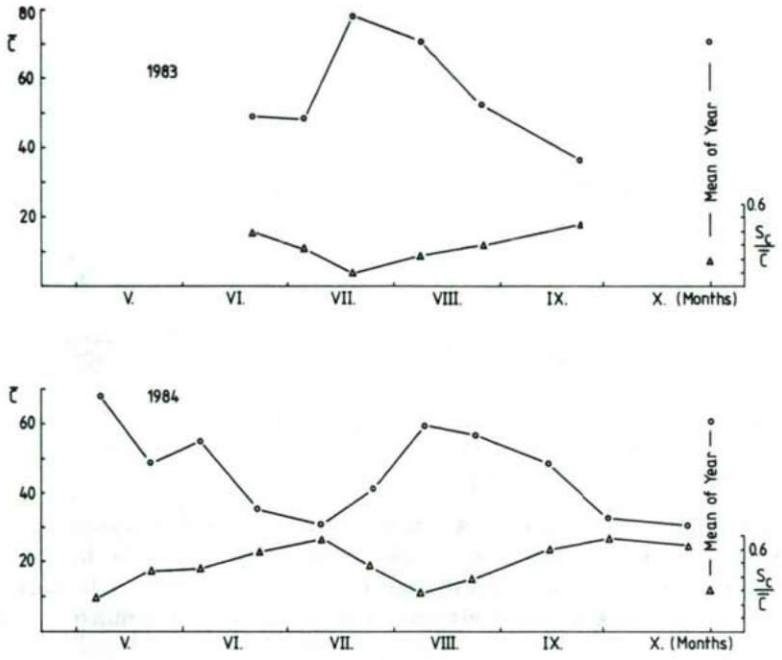

Fig. 4. Averages and variational coefficients of the Renkonen similarity indexes of *Acridoidea*-communities in the time-periods of the dish–trap samplings.

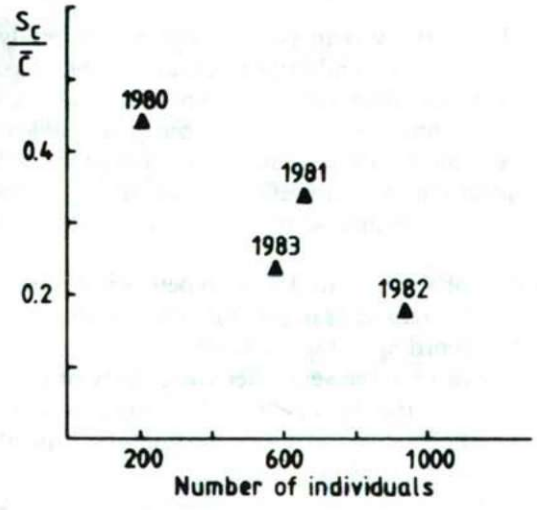

Fig. 5. Changes of the variational coefficient values in the function of the total individual numbers of the dominant species (*Euchorthippus* and *Calliptamus*) in the years 1980–83, on the basis of Barber–trap recordings.

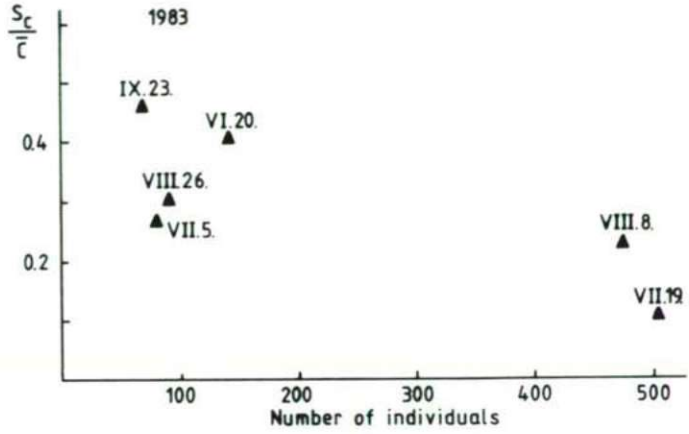

Fig. 6. Changes of the variational coefficient values in the function of the total individual numbers of the dominant species (*Euchorthippus* and *Calliptamus*) in the sampling time-points of the 1983 dish–trap collecting.

question, because the results of 4 years are at disposal for comparison. The relationship between density and heteromorphic indication is unambiguously negative here (Fig. 5). The changes in seasonal density, which may be estimated on the basis of the dish-traps, too, exert similar effect on the heteromorphic indication (Fig. 6).

3. Correlation of similarity values

A further possibility of study is to perform correlation analysis between the data-pairs corresponding to the similarity matrices of the vegetation and the insect-community. In such case data can be obtained in respect to the similarities and deviations, resp., regarding the spatial heteromorphy indication of the two communities in the qualification of the similarity to each other of the various sites (Table 3 and 4). The linear correlation coefficient (L) values are indicated in every case, other correlational data are only shown in case they surpass the value gained for L.

According to the data of Table 3. the deviation between the linear and non-linear correlation coefficients is not significant in general. The correlation values are higher for 1983 than for 1984. Accordingly, the correlation between the behaviour of the two community types is greater in the year when the density of the grashoppers and the homomorphic degree of the habitat is also higher. From the coefficients calculated on the basis of the Barber–traps, the outstanding value obtained for 1982 can be back to similar reasons (Table 4).

Furthermore, it was also studied what correlational connections could be demonstrated between the grashopper communities at the dish-trap habitats between 1983–84 and their close seasonal time-points (Table 5), as well as between 1980–83 at the Barber–trap habitats (Table 6).

Table 3. Correlation between the vegetation and the Renkonen similarity values of the *Acridoidea*-communities, on the basis of dish–trap collecting (correlation calculated on the basis of L: linear-, LOG: logarithmic-, EXP: exponential-, POW: power index functions)

1983			1984		
VI.20.	0.44 L	$p<0.001$	V.7.	0.36 L	$p<0.01$
	0.50 LOG			0.38 LOG	
VII.5.	0.48 L	$p<0.001$	V.22.	0.48 L	$p<0.001$
VII.19.	0.56 L	$p<0.001$	VI.5.	0.48 L	$p<0.001$
	0.62 LOG				
	0.63 POW		VI.22.	0.18 L	$p>0.1$
VIII.8.	0.66 L	$p<0.001$	VII.10.	0.41 L	$p<0.001$
	0.70 LOG				
	0.70 POW		VII.25.	0.21 L	$p>0.1$
VIII.26.	0.47 L	$p<0.001$	VIII.9.	0.46 L	$p<0.001$
	0.48 EXP				
			VIII.24.	0.20 L	$p>0.1$
IX.23	0.17 L	$p>0.1$		0.24 EXP	$p<0.1$
	0.18 EXP				
	0.20 LOG		IX.14.	0.15 L	$p>0.1$
	0.23 POW	$p\sim0.1$			
			X.2.	0.13 L	$p>0.1$
All year:	0.60 L	$p<0.001$		0.23 LOG	$p\sim0.1$
	0.61 EXP				
	0.64 LOG		X.25.	0.27 L	$p\sim0.05$
	0.65 POW		All year:	0.42 L	$p\sim0.001$

Table 4. Correlation between the vegetation and the Renkonen similarity values of the *Acridoidea*-communities, on the basis of Barber–trap recordings

1980	0.33 L	$p<0.01$
1981	0.30 L	$p<0.02$
	0.32 POW	$p\sim0.01$
1982	0.53 L	$p<0.001$
1983	0.18 L	$p>0.1$
	0.21 POW	$p<0.1$

Table 5. Correlation of the Renkonen similarity values of *Acridoidea*-communities in 1983-84 at the dish-trap collecting sites

1983.VI.20. x 1984.VI.22.	0.50 L	$p<0.001$
1983.VII.10. x 1984.VII.25.	0.51 L 0.53 LOG	$p<0.001$
1983.VIII.8. x 1984.VIII.9.	0.721 L 0.722 LOG 0.728 POW 0.729 EXP	$p<0.001$
1983 x 1984	0.81 L 0.82 LOG 0.82 POW	$p<0.001$

Table 6. Correlation matrix of the Renkonen similarity values of *Acridoidea*-communities on the basis of Barber-trap recordings

	1980	1981	1982	1983
1980		0.38 L $p\sim0.001$	0.28 L $p\sim0.02$	0.069 L $p<0.1$
1981			0.43 L $p<0.001$	0.26 L $p<0.05$
1982				0.33 L $p<0.01$
1983	0.074 LOG $p>0.1$	0.29 LOG $p<0.02$	0.34 LOG $p<0.01$	

On the basis of the results, much higher correlational coefficients could be found for the sites trapped by dish-traps than at the patches where Barber-traps were used. Evidently, definite standpoint concerning the evaluation of the correlational relations would not be suitable here, either, nevertheless, we can conclude that there must be considerable differences in community-structure in the two habitat- combinations, or the underpresentation of the grashopper populations in the Barber-traps causes stronger stochasticity in the composition of the collected material.

4. DIVERSITY RELATIONS

There are significant deviations between the diversity-changes of the plant- and grashopper-communities living at the various sites (Fig. 7). Since the insect community in question is herbivore, it may be striking that the *Acridoidea*-communities have greater diversity at patches with small plant-diversity. However, the analysis of these patch-types points to the fact that these possess the physical conditions (small surface coverage, higher relief, xerothermic relations) favourable for the xero- and geophyl species. At the same time these habitats differ from each other in respect to their successional condition. The EU, CY and PFP are habitats of initial- and early-successional stage, while the FV ≫ types are the representatives of natural grasses of late-successional stage. The degree to which the successional stage of a habitat may be determinant on the species composition of the insect community living at it — in our case the grasshopper community — is shown by the following example. In both years of the dish-trap studies the geophyl species (*Oedipoda coerulescens* L. 1758, *Oedaleus decorus* GER. 1826, *Celes variabilis* PALL. 1771) and the *Dociostaurus brevicollis* EVER. 1848 of Southern distribution occurred with greatest individual number in the habitats of initial succession, having small coverage (EU and CY). On the contrary, at the natural grasses (FV ≫ PFP and FV ≫ EU) the listed geophyll species did not occur at all, or only 1–1 individual, and the *D. brevicollis* was only represented in 20–50% of the former value.

It is also a characteristic feature that in 1984, apart from the drastic decrease in the total individual number of the *Acridoidea* there was an increase in the diversity of the grasshoppers at every sapmled site. The presumable explanation to this is the change in the population-ratios accompanying the decrease in the individual number,

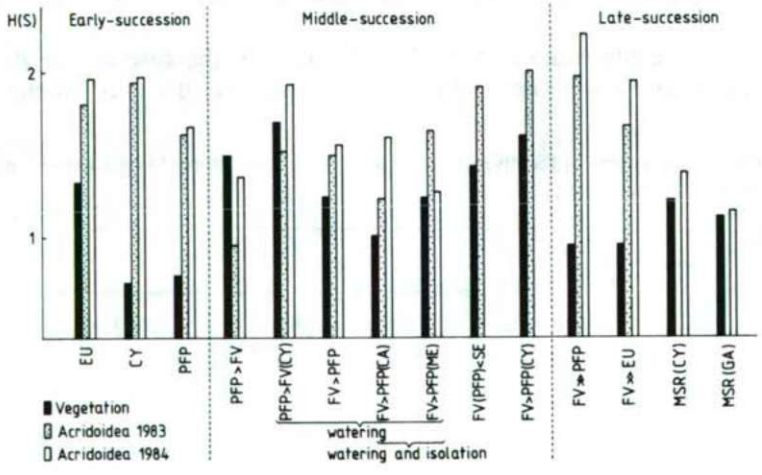

Fig. 7. Diversity values of the vegetation and the *Acridoidea* communities at the various succession staged habitats, on the basis of dish-trap collecting.

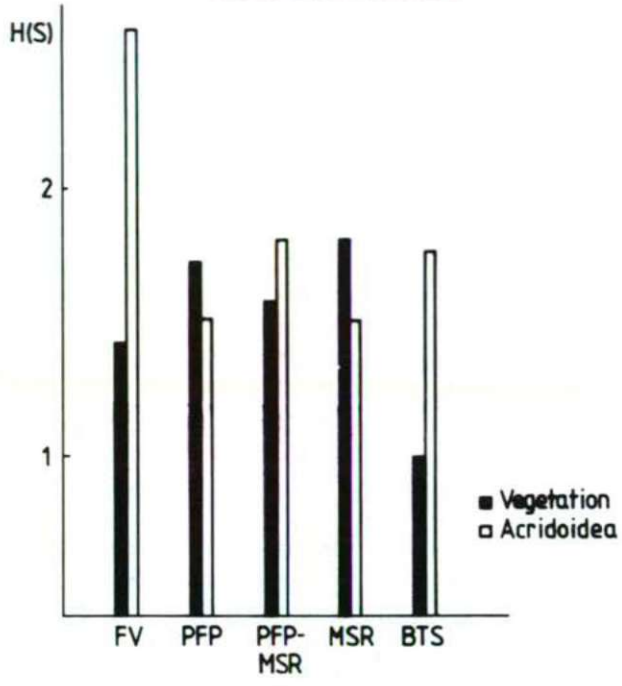

Fig. 8. Diversity values of the vegetation and the *Acridoidea* communities at the Barber-trap patch-types in 1981.

first of all the decreased ratio of two dominant species (*Calliptamus italicus* L. 1758 and *Euchorthippus declivus* BRIS. 1848), and thus the increase in the evenness component of diversity.

Similar diversity-relations were found earlier in the case of the Barber–trap studies, too (Fig. 8), since here, also a high grasshopper-diversity accompanied the

Table 7. Correlation matrix of the diversity of vegetation and grasshopper-communities on the basis of the dish–trap collecting

	1	2	3
1(Vegetation)	–	–0.15 L –0.20 POW	–0.21 L –0.26 LOG
2(Acrid.1983)		–	0.83 L 0.85 EXP $p < 0.001$
3(Acrid.1984)			–

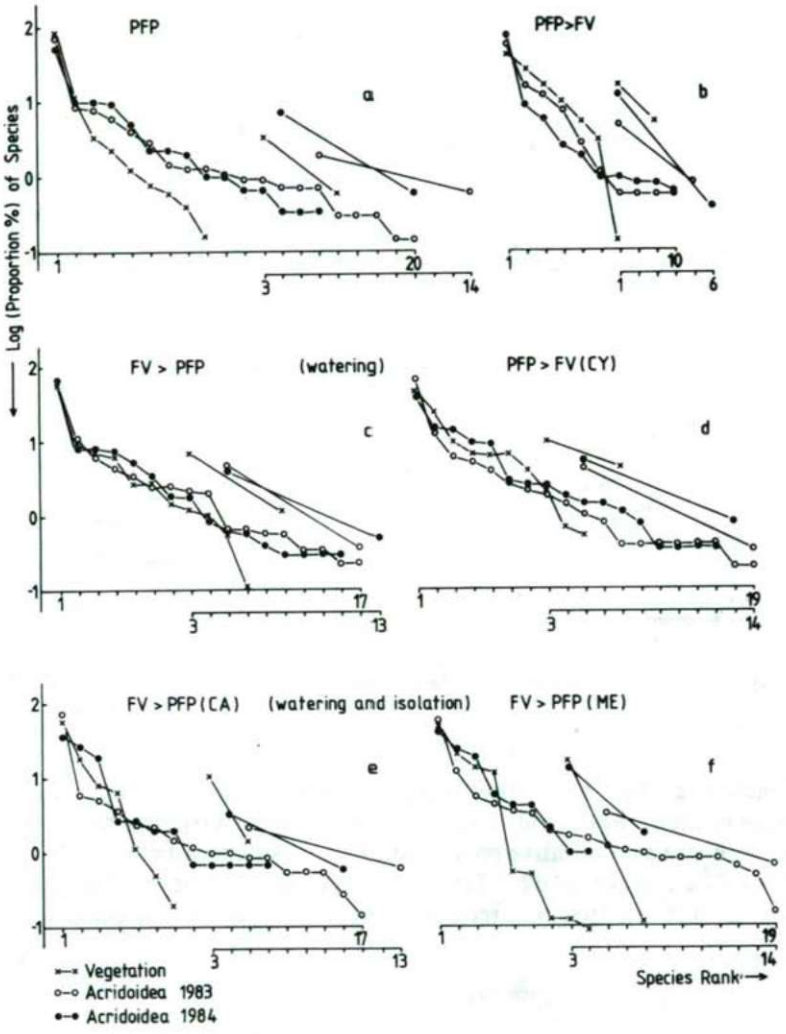

Fig. 9.a–f. Dominance-diversity curves at the succesional habitats of the dish-trap collecting.

lower plant-diversity of the *Festucetum vaginatae* (FV). An unexpected high grasshopper-diversity was manifested in the *Brometum tectoris Secale facies* (BTS) degraded association as well. This was striking because other insect communities (*Cicadinea*, *Heteroptera*, *Formicoidea*) showed the lowest diversity here (see GALLÉ et al. 1985b). The divergent behaviour of the grasshoppers can probably be explained by the fact that the xerothermic conditions caused by degradation are favourable for this insect-group of high heat demand.

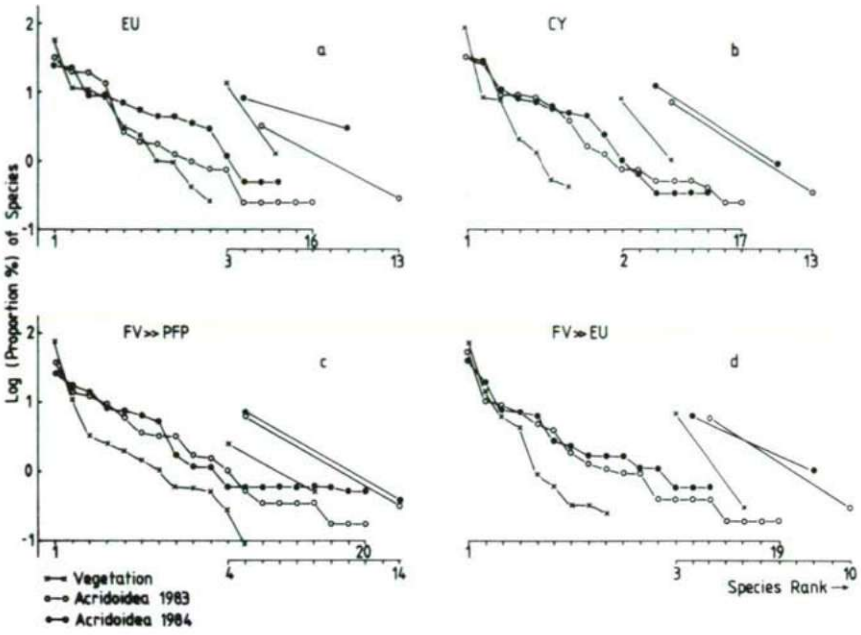

Fig. 10.a–d. Dominance-diversity curves at the primary- (a,b) and late-successional (c,d) habitats of the dish–trap collecting.

Concluding from the contradictory tendencies found in the above diversity-relations the result of the correlation study between the diversities is not striking (Table 7), since in every case negative connection was experienced between the vegetation- and *Acridoidea*-diversities. This fits well to the Barber–trap studies, where 'r' was found to be -0.388 in 1981. On the contrary, there is a tight correlation between the

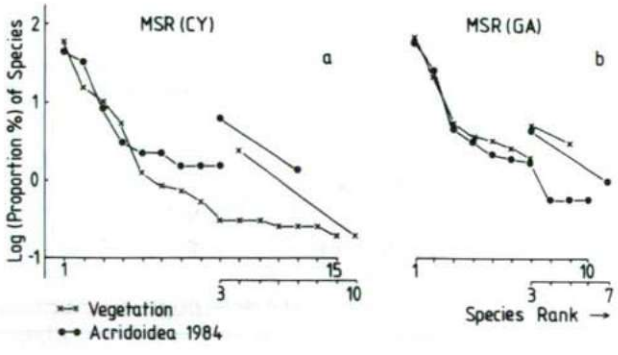

Fig. 11.a–b. Dominance-diversity curves in the associations of lower space level.

diversity values of the grasshopper communities, referring to the fact that the vegetational background of our trap study can be evaluated as the habitat of grasshopper-groups of stable community structure.

5. DOMINANCE-DIVERSITY

Beyond the diversity-relationships, the dominance-diversity curves as well as the slopes of their median section may provide help for the further characterisation of the community tructure (Figs. 9–11). The curves give good illustration of the community structure deviations at the 12 trap sites. The Figures also show the straight lines drawn with the slopes obtained pertaining to the median section of the dominance-diversity curves. Their unchanged nature between the years can be applied for the indication of the structural stability.

At the medial-successional *Potentillo-Festucetum pseudovinae* community habitats (Figs. 9.a–f.) the species-richness of the vegetation is balanced, the number of species ranges from 7 to 11. The number of species of the grasshoppers is high (17–20) and at the undisturbed (non-treated) places they show rather similar community structure in both years. At two sampling sites, however, the unfavourable effect of isolation on the arrangement of the grasshopper-communities is rather striking, since following this perturbation the number of species of the grasshoppers decreased from 17 to 12, and from 19 t0 9, resp., in 1984 (Figs. 9.e–f.). At the PFP > FV labelled sample site the modification of the dominance-diversity curves for the grasshoppers and the low species number are striking, as due to the great similarity of the vegetation the organization of grasshopper-groups having structure similar to the other places transitory in succession would be expected (Fig. 9b).

At the primary- (EU and CY) and late-successional staged habitats having *Festucetum vaginatae* (FV $\gg$) dominance (Figs. 10.a–d.) the number of plant species is 7-10 and 9-12, resp. The number of species of the grasshopper communities is high here, too, (14–20) however, the individual distribution shows less evenness than at the median-successional patches. The straight lines indicating stability show varying picture.

According to expectations, the number of species of the grasshopper communities is the lowest (9–10) in the *Molinio-Salicetum* association (MSR). It is interesting that at the two collecting sites of MSR the structure of the grasshopper-groups are rather similar although the composition of vegetation is different.

References

ANDRZEJEWSKA, L. and GYLLENBERG, G. (1980): Small herbivore subsystem. In: Grasslands, systems analysis and man (ed.: BREYMEYER, A.I. and VAN DYNE, G.M.). — Cambridge Univ. Press, Cambridge 201–267.

CAPINERA, J.L. and SECHRIST, J.L. (1982): Grasshopper (*Acrididae*) — Host plant associations: Response of grasshopper populations to cattle grazing intensity. — Can. Ent. *114*, 1055–1062.

EVANS, E.W., ROGERS, R.A. and OPFERMANN, D.J. (1983): Sampling grasshoppers (*Orthoptera:Acrididae*) on burned and unburned tallgrass prairie: Night trapping vs. sweeping. — Environ. Entomol. *12*, 1449–1454.

GALLÉ, L., HORNUNG, E.H., Szőnyi, G.D., GYŐRFFY, GY. and KINCSEK, I. (1985a, in press): Komplex ökológiai vizsgálatok homokpusztai gyepen a Kiskunsági Nemzeti Park területén (Complex ecological studies of a sandy grassland in Kiskunság National Park. In Hungarian). — In TÓTH, K. (szerk.): Tudományos kutatások a Kiskunsági Nemzeti Parkban, Hungexpo

GALLÉ, L., GYÖRFFY, GY., KÖRMÖCZI, L., SZŐNYI, G.D. and HARMAT, B. (1985b, in press): Különböző közösségtipusok élőhely heterogenitás indikációja homokpusztai gyepen (Indication of space-heterogeneity from various community types on sandy soil grassland. In Hungarian). — OKTH Évkönyv

GAUSZ, J. (1970–71): Faunistical and ecological observations on the *Orthoptera* fauna of the Hungarian Plain. — Tiscia(Szeged) *6*, 67–80.

MONK, K.A. (1985): Effect of habitat on the life history strategies of some British grasshoppers. — J. Anim. Ecol. *54*, 163–177.

MURDOCH, W.W., EWANS, F.C. and PETERSON, C.H. (1972): Diversity and pattern in plants and insects. — Ecology *53*, 819–829.

PFADT, R.E. (1982): Density and diversity of grasshoppers (*Orthoptera:Acrididae*) in an outbreak on Arizona Rangeland. — Environ. Entomol. *11*, 690–694.

PFADT, R.E. (1984): Species richness, density, and diversity of grasshoppers (*Orthoptera:Acrididae*) in a habitat of the mixed grass prairie. — Can. Entomol. *116*, 703–709.

SOÓ, R. (1965–1980): A magyar flóra és vegetáció rendszertani és növényföldrajzi kézikönyve I–VI. (Synopsis systematico-geobotanica florae vegetationisque I-VI.) — Budapest

SOUTHWOOD, T.R.E., BROW, V.K. and READER, P.M. (1979): The relationships of plant and insect diversities in succession. — Biol. J. Linn. Soc. London *12*, 327–348.

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